From: Steve Ross 630 252-9510, 401-B3212, skross@anl.gov
To: Detector Pool
Subject: APD detector, version 2 “bottle” box
Date: 2/8/2007 Apd12_memo1b.doc

We have a second version of mechanical enclosure for avalanche photodiode (APD) [1] x-ray detectors. Multiple copies are in the APS Detector Pool. This version is patterned after existing units at sector 3, and has the APD in a necked down “bottle” shaped section.   See also Aug 2006 memo on “Version 1” box, and EG&G data sheet.

We continue the offer that we will put your supplied Perkin-Elmer Inc.1 cm^2APD into an enclosure, and supply the RF amplifier, for no cost to APS beamlines. The RF designs are similar to the version 1 box, and it in turn is very similar to work by Baron [2] and Deschaux [3] (SPRing8/ESRF).   The amplifier is AC coupled, and has a gain of about 60 dB (1000), bandwidth > 1 GHz. (We also stock a “Low Gain” version, 40 db (100)). The APD is commercially available. [4]   .

Inside is a Perkin-Elmer C30703FH-200T 1cm x 1 cm, 210 um thick, silicon avalanche diode, typically covered with a thin piece of aluminized mylar. The user must supply a APD high voltage bias of some +280 to +330 volts, (5 uA approx), through an SHV cable, to create an APD gain of about 100. I typically use a Stanford PS350, which you can try out via the APS Detector Pool. The user must also supply an electronics supply voltage of about +11 volts, 0.04 A through a BNC cable. The RF pulses come from a BNC into a 50 ohm load. Optimum values for these voltages are typically written on the unit itself.

The EG&G detectors plus RF amplifiers put out a 200 mV negative going signal (though this can be reversed with an RF transformer). They have been tested so far as counting detectors to about 20 MHz before things like baseline shift stop things from working, but this will vary with your application. False count rates depends on voltages and of course thresholds, and vary between APD devices, but are in range of <0.1 Hz.

DETECTOR OPERATION.

CAUTION—this detector requires high voltage, approximately +300 VDC. Exercise due care with this HV, low current (microamp) supply. Turn off HVDC when touching the unit. The case is properly grounded, but the HVDC does exist on the silicon detector itself, in the narrow front neck of the unit.

Operation is fairly straight-forward, though you should be careful. First terminate the RF output in a 50 ohm load. Use the best quality coax you have, and avoid BNC feedthrus. This is just good RF practice. The best coax is semi-rigid. Also set the limits on the high voltage direct current (HVDC) supply. Typically set limits to +340 VDC, 30 uA.

Then connect the low voltage and high voltage supplies. It is not that important, I usually turn on first the low voltage supply (+10 vdc typical, range +9.8 to +10.8 v). It should draw about 0.03 amps. Then turn on the HV supply, set at low voltage, say +50VDC. Over a period of several seconds to a minute, bring up the HV to the desired level. (+320 volt typical, extended range +200 to +340 vdc DC). Its current should read about 3 uA, more if there is bright room light. If you come up too fast, then the bypass capacitors in the circuitry will draw current. This can trip the limit points on the HVDC supply -- mainly just an irritation. Turn off in reverse manner, gradually lowering the HVDC (not vital, just good practice.)

This unit typically takes scattered x-ray beam, not direct beam. The amplifier gains are such that it is a counting detector. If you want a current –mode detector see me, we have this permutation too.

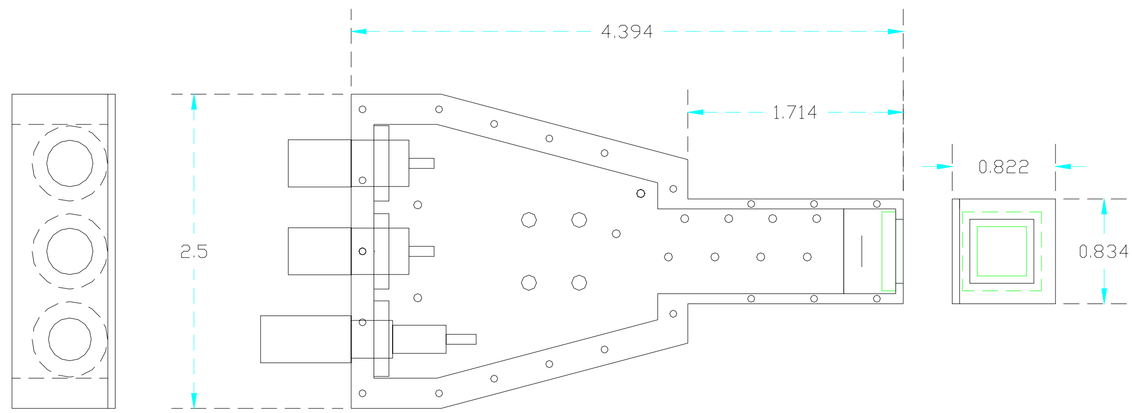
Mistakes you should avoid – reverse biasing the diode, please do not put negative voltage on the HVDC. Some of my units are protected, but not all (an action item). Please do not exceed about +12 vdc on the amplifier bias.

If for some reason the amplifier oscillates (usually at about 3 GHz) , then lower the DC voltage a bit. If you have to go below about 9.5 VDC, then just contact me.

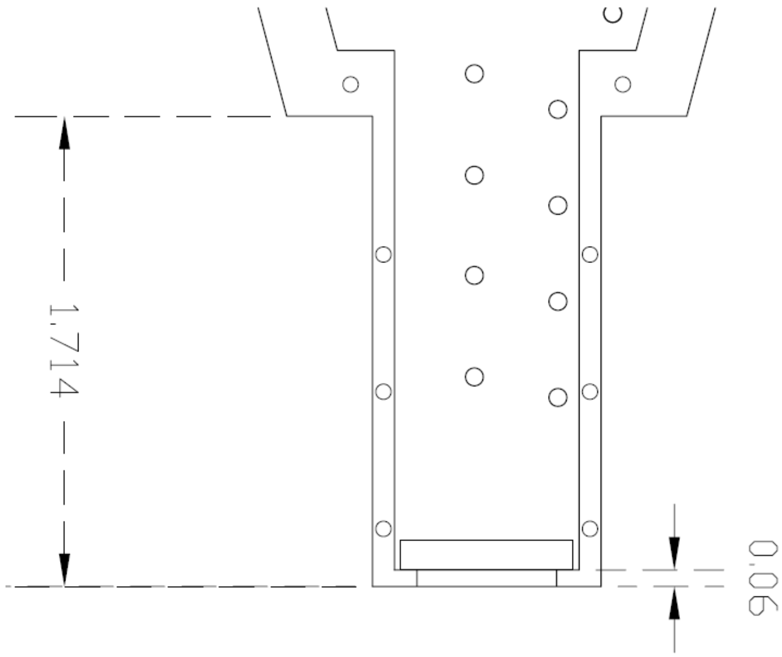
The only valuable thing in the detector is the APD itself. The RF amplifiers cost about $10.

OTHER SUPPORT ELECTRONICS: To process further the fast output pulse, typical electronics (which the Detector Pool does not stock) include OrTEC pico Timing discriminator, model 9307, which takes a -25 mV to -1 v fast pulse and outputs a NIM pulse or a TTL pulse. The fast NIM pulse can be turned into a fast TTL pulse via an APS/Control Group TIM102 card.

Dimensions of box, inches. APD itself is shown in green on this top view, and end-on view. Top BNC is RF out, middle BNC is DC supply in, bottom SHV is HVDC in. [APD12_RFBOX_V18.dwg, since slightly modified to APD12_RFBOX_V19.dwg]

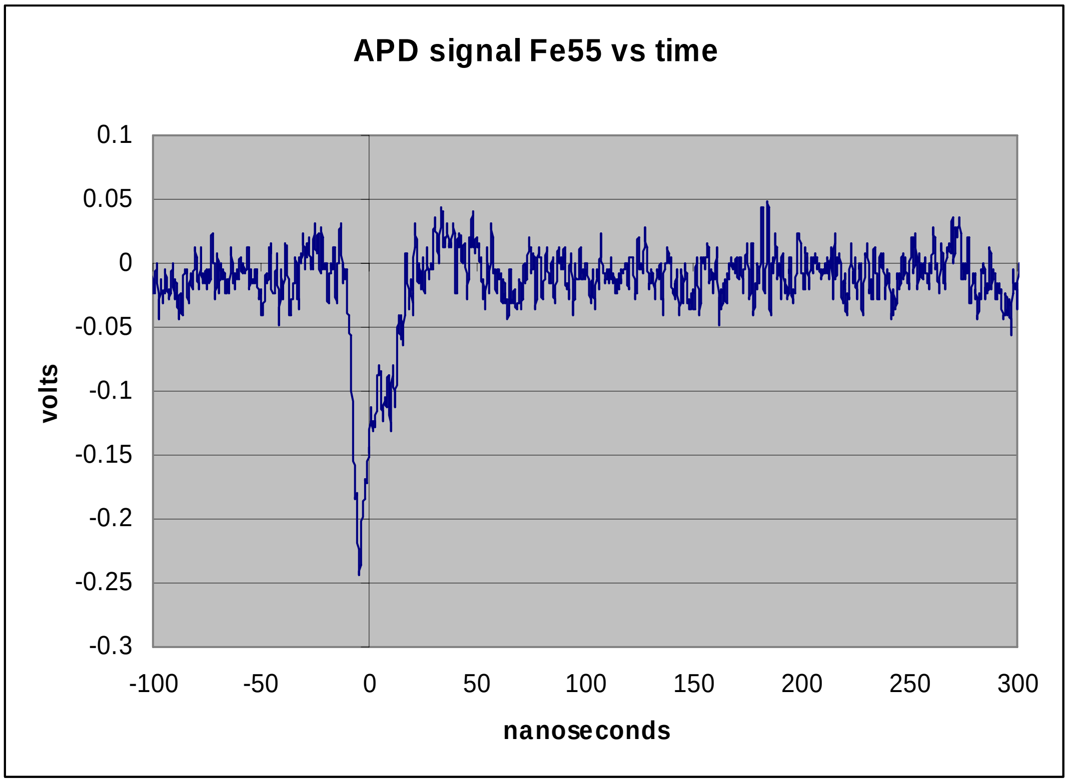


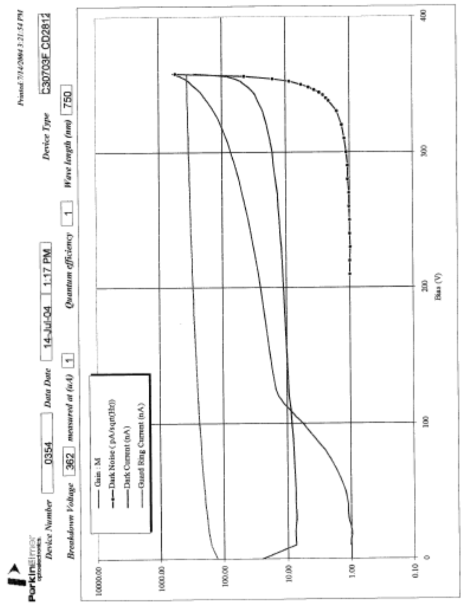
Detail of front of box, with APD recessed slightly, 0.06 inch.

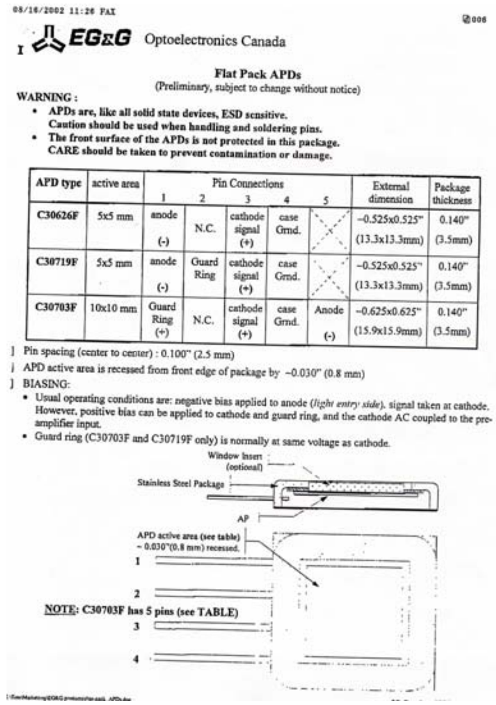


Typical x-ray response. (070207_161935.csv)

Rise and fall times of the APD can be adjusted somewhat with bias. This is an Fe55 5.9 keV x-ray response. Typical noise about 12 mV RMS, typical peak signal about -200 mV.







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EG&G Optoelectronics Canada

Flat Pack APDs
(Preliminary, subject to change without notice)

WARNING :

- **APDs are, like all solid state devices, ESD sensitive. Caution should be used when handling and soldering pins.**
- **The front surface of the APDs is not protected in this package. CARE should be taken to prevent contamination or damage.**

APD type	active area	Pin Connections 1	2	3	4	5	External dimension	Package thickness
C30626F	5x5 mm	anode (-)	N.C.	cathode signal (+)	case Grnd.		~0.525x0.525" (13.3x13.3mm)	0.140" (3.5mm)
C30719F	5x5 mm	anode (-)	Guard Ring	cathode signal (+)	case Grnd.		~0.525x0.525" (13.3x13.3mm)	0.140" (3.5mm)
C30703F	10x10 mm	Guard Ring (+)	N.C.	cathode signal (+)	case Grnd.	Anode (-)	~0.625x0.625" (15.9x15.9mm)	0.140" (3.5mm)

- Pin spacing (center to center) : 0.100" (2.5 mm)
- APD active area is recessed from front edge of package by ~0.030" (0.8 mm)
- BIASING:
  - Usual operating conditions are: negative bias applied to anode (*light entry side*). signal taken at cathode. However, positive bias can be applied to cathode and guard ring, and the cathode AC coupled to the pre-amplifier input.
  - Guard ring (C30703F and C30719F only) is normally at same voltage as cathode.

NOTE: C30703F has 5 pins (see TABLE)

Sample data sheet from Perkin Elmer.

References:

[1] R.J. McIntyre, IEE Transactions on Electron Devices, Vol ED-13, No. 1, January 1966. Original discussion of APD noise.

[2] see for example A fast, convenient, X-ray detect by A.Q.R. Baron, R. Ruffer, J. Metge, Nuclear Instruments and Methods in Phys Res A 400 (1997) 124-132.

[3] DESCHAUX-BEAUME Thanh Hai, private communication. While this is not a great reference, Thanh has been quite active in this field, and has taught me quite a bit. Existing commercial designs are also based on his work.

[4] Frederic Laforce, Perkin Elmer Inc.
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